# Water conservation-Real life problem

**Nature of the task**

A real-life problem where students were given the opportunity to apply mathematics in a real-life context, reflect upon and evaluate their findings.
The choice of:

- which country to investigate
- what specific water issue to investigate
- criterion for effective design

was decided upon by each of the students.

**Criteria assessed**

Criteria A, C and D

**Time allocated**

In class Time: 40 minute introductory session
10 minute individual tutorial time every two weeks

Total Time: Assignment was submitted 6 weeks after the introductory session

**Background to the task**

This task was given as a part of Area and volume and Solids units of study, focused on investigating surface area and volume within given parameters.
The task asked students to identify an environmental water issue, specific to a country or region and design the most suitable shape to solve that individual problem. This allowed students to focus their planning on an idea that appealed to them, to put the idea of a real problem into to context and to allow them the choice of what and how to investigate their chosen shapes.
They were asked to relate their design to their chosen problem which gave them the opportunity to research in depth.
The students were required to:

- Use previous knowledge of area to calculate material used
- Select and apply techniques of drawing nets within given parameters to reason a solution
- To use technology and known strategies to illustrate and communicate ideas to the reader
- Identify variables and tabulate results to justify their final solution
- Evaluate the reliability of their results
- Reflect on the application of their chosen shape in relation to their chosen problem

- Research an environmental water issue and adapt their solution to propose a solution

The students worked individually.
The situation was unfamiliar and related to a taught aspect in semester 1.
Some knowledge was from previous units of study in G9 and related to the strand focus of Geometry.
The activity was unsupervised but two weekly discussion meetings were held with the teacher to update and discuss progress.
All assignments were submitted to T in line with the school Academic Honesty Policy.
Students were required to complete a bibliography of research sites and materials used.

**How it was assessed**

The final product was a report, with supporting mathematical evidence of calculations completed and justification of results produced.
Students were provided with a task sheet that included

- Introduction
- Area of interaction focus
- Unit question
- Task specifics
- Things to consider
- What to hand in
- Assessment details
- Research sites
- Published descriptors
- Cover sheet with format for discussion notes

# Grade 10 Task sheet- Water conservation

## Information:

Clean water has become a global issue but is particularly important in countries that have no structured clean water supply for the whole population. Dirty water accounts for a high percentage of child deaths in many third world countries. Children die from diseases carried in untreated or contaminated water. The cost of providing water collection tanks is beyond many rural communities and so they continue to use tainted water supplies.

## Area of Interaction:

Environments and Approaches to Learning

## Unit question:

**What strategies do I need to use when I investigate how to design an effective water container for my chosen geographical region?**

## Task:

- To design a water tank that holds the maximum volume of water for a given amount of material. Material is 5m by 5m
- To consider the design used to make it the cheapest by discarding the least amount of material

## Things to consider:

- To be able to compare the volume of a tank against the amount of material you use. Decide which dimension you could vary
- Consider what shape is easiest to make and how it could be easily constructed to waste the least amount of the material (suggestion-investigate 3 solids)
- Research a country/region that has clean water issues and relate you solution to how that community could be helped- by cost, design or any ideas of your own

## What to hand in:

- Initial ideas
- Report to include
    1. All calculations with a clear explanation of mathematical **methods** used
    2. Supporting representations to justify your solution
    3. Evaluation of the mathematics you used to find your solution
    4. How to apply your findings in **real life**
- Remember to include you bibliography

## Assessment:

This task will be assessed using criteria **A C** and **D**

Use the rubric to help you organize your work

**REMEMBER- IT IS THE QUALITY AND CONTENT THAT WILL DETERMINE YOUR LEVEL**

**YOUR TEACHER DOES NOT GIVE LEVELS, YOU ACHIEVE THEM THROUGH THE WORK YOU PRESENT**

Your deadline is

## Research sites:

These are some available sites to help you in your research

**http://www.bushmantanks.com/**

**http://www.bluescopewater.com/**

**http://www.watertanks.com/**

# Water Tanks

# Introduction

Clean water is a global issue. In places where there is no structured distribution of water – people have to use containers to store larger amounts of water. Communities tend to use dirty water. Without containers to hold "clean, processed water," adults and especially children can die from water – infections. The task of solving this issue is to use the materials; *efficiently*.

Task

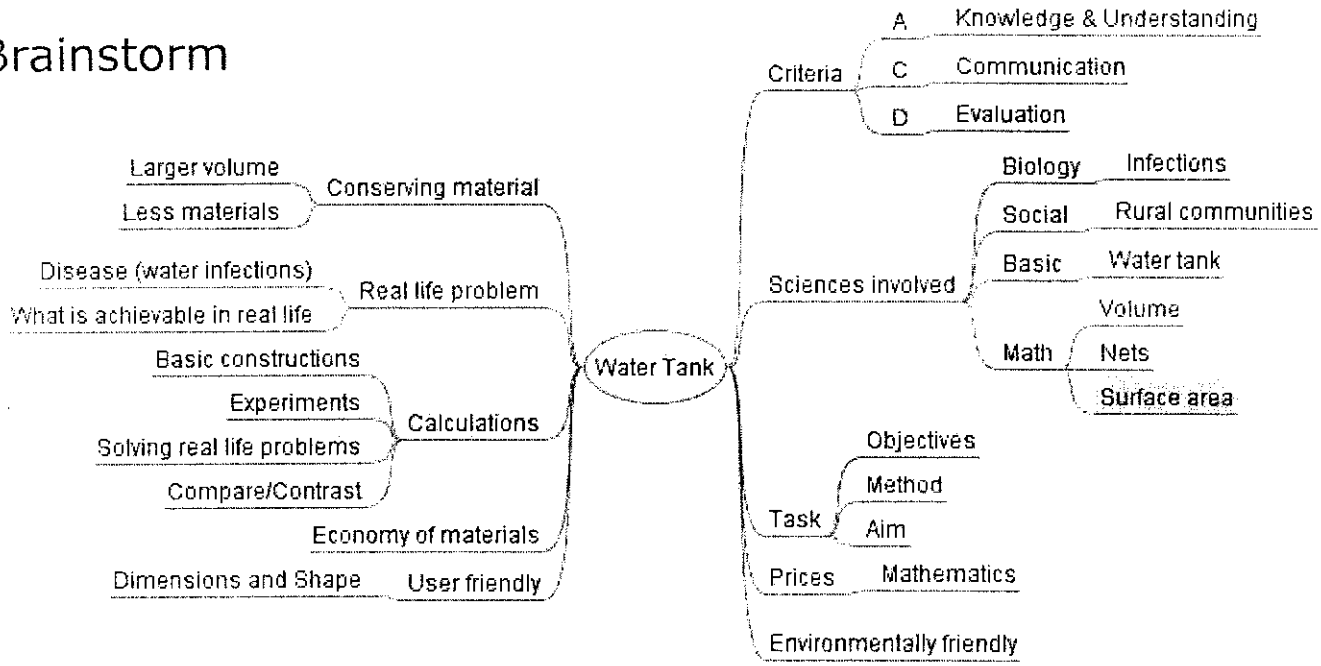
Design water tank
Consider design to be maximized. Use **more** materials – for **larger** volume. Dimensions to vary with **materials used**. Compare and contrast nets in **real life** situations.

What to hand in?

Initial ideas (brainstorm & planning)
Report
Evaluation
Bibliography

# Planning

## Brainstorm




## Time line

| Date | What | Presentation |
|---|---|---|
| 1st October | Introduction stage (research – understand task) | Oral/Notes |
| 10th October | Planning stage (what needs completion/guide) | Written |
| 15th October | Investigation stage | Written/Experiments |
| 3rd November | Conclusion | Written |
| 6th November | Evaluation | Written |
| 7th November | Correction | Read-through |

## Skills/Method

1. Knowledge and understanding of task.
2. Research – points.
3. Compare different 3D shapes and their volumes.
4. Multiple drafts.
5. Materials and efficiency.
6. Final draft.

# Objectives

Different shapes have different advantages. In my task I shall include several comparisons of different "basic" shapes.

**Research**
- Volume
- Shape
- Dimensions
- Formula (calculating area, volume)

**Plan**
- What needs completion
- Timeline (when)
- How?

**Investigation**
- Writeup
- Real life situation logistics
- Considerations
- Input/Output
- Storage of water mechanics
- Issues: dirty water or lack of water?

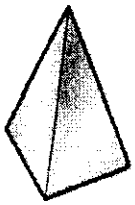
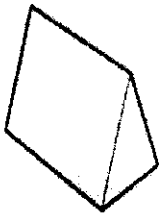
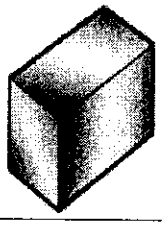
**Conclusion**
- What tank is best?
- Look back at task
  - What kind of tank you have?
  - Efficiency of use.
  - Evaluation of use.
  - Use/User friendly?

**Evaluation**
- Critical thinking
- Task
- Completion of work
- Deadlines?
- Reflect on process

**Questions involved**

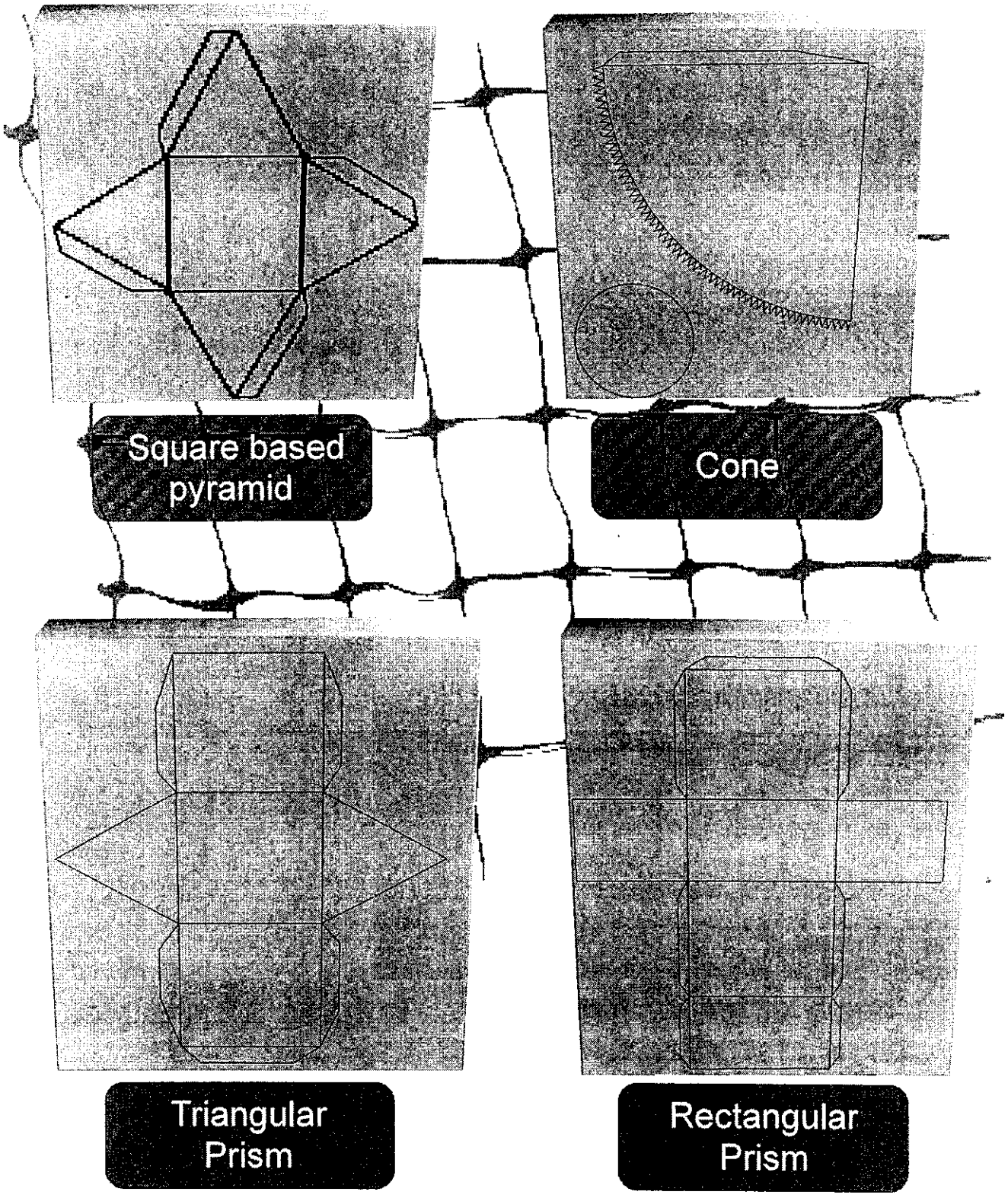
1. How to collect water?
2. How to conserve water?
3. How to store water?

Candidates

| | |
|---|---|
| Square (based) pyramid |  |
| Cone |  |
| Triangular prism |  |
| Cube |  |
| Cylinder |  |
| Sphere |  |

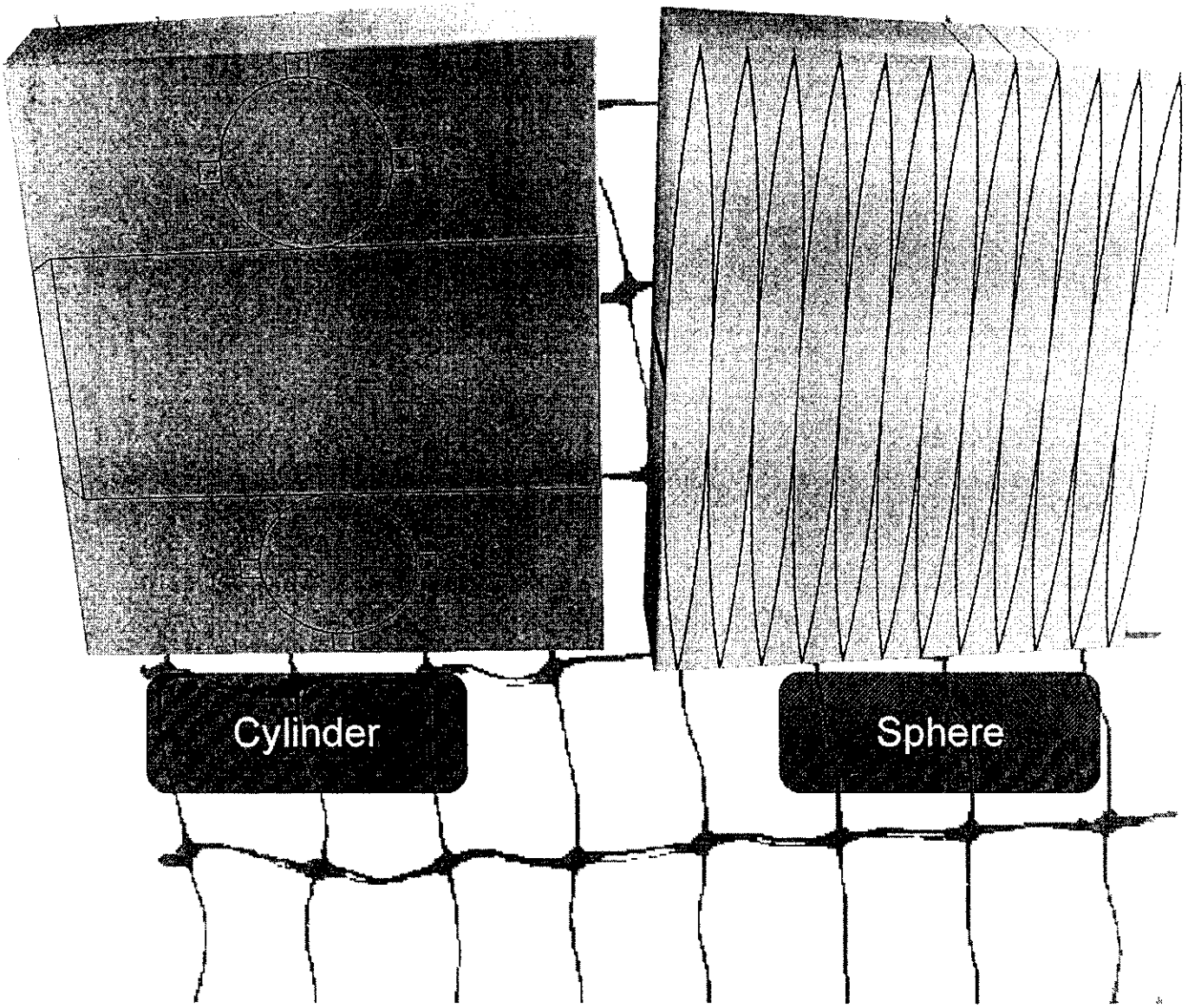
# Compare & Contrast

Nets



# Compare & Contrast

Nets




There are 6 different nets above. In total – 6 shapes.
The task was to choose only 3 shapes and their nets.

# Laws

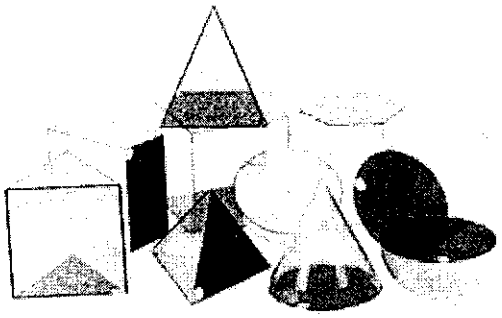
## Shapes

Each shape has certain laws which define it.
Here I will present the laws of the shapes I have chosen, so that the reader does not get confused.

**•Cube:**
- 6 square faces.
- 3 faces meet at vertex.
- All angles inside 90*

**•Cylinder:**
- 2 congruent circular faces and 1 cylindric plane.

**•Cone:**
- Shape that tapers from flat round base to a vertex.
- The cone I used has a round base, with the vertex 90* from the center of the circle.

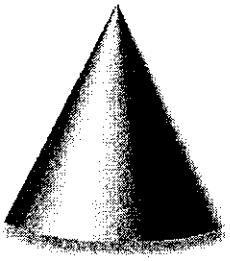


## Volume

*Cylinder:* $V = \pi r^2 h$

*Cube:* **Length x Width x Height**

*Cone:* $V = \frac{1}{3}\pi r^2 h.$



## Surface Area

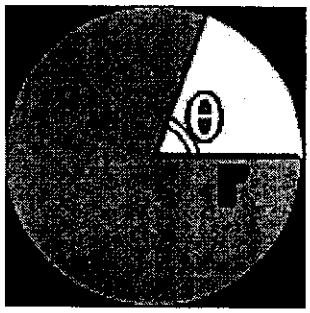
Cube:
[6s] where s = area of 1 square face

Cylinder:
[Area of CS] x Length

Cone: Area of sector =

$\frac{\theta}{360}\pi^2$

Area of base = $\pi r^2$



# Variables

## Difference

Different shapes have different rules applied to them. Therefore I created a list of all the variables that I can change for a particular goal. My goal is to establish the variables for maximizing the surface area of a shape. Diagrams on next page.

## Cube [1]

The laws of different shapes are stated on page 8 – therefore I will try to list variables applied to different shapes, by investigating the maximum surface area.

| Independent variable | Dependant variable | Constant variable |
|---|---|---|
| • Length of the sides<br>• Area of the components [squares] | Area of the net | • All interior angles are 90*<br>• All components [squares] are of equal dimensions |

## Cylinder [2]

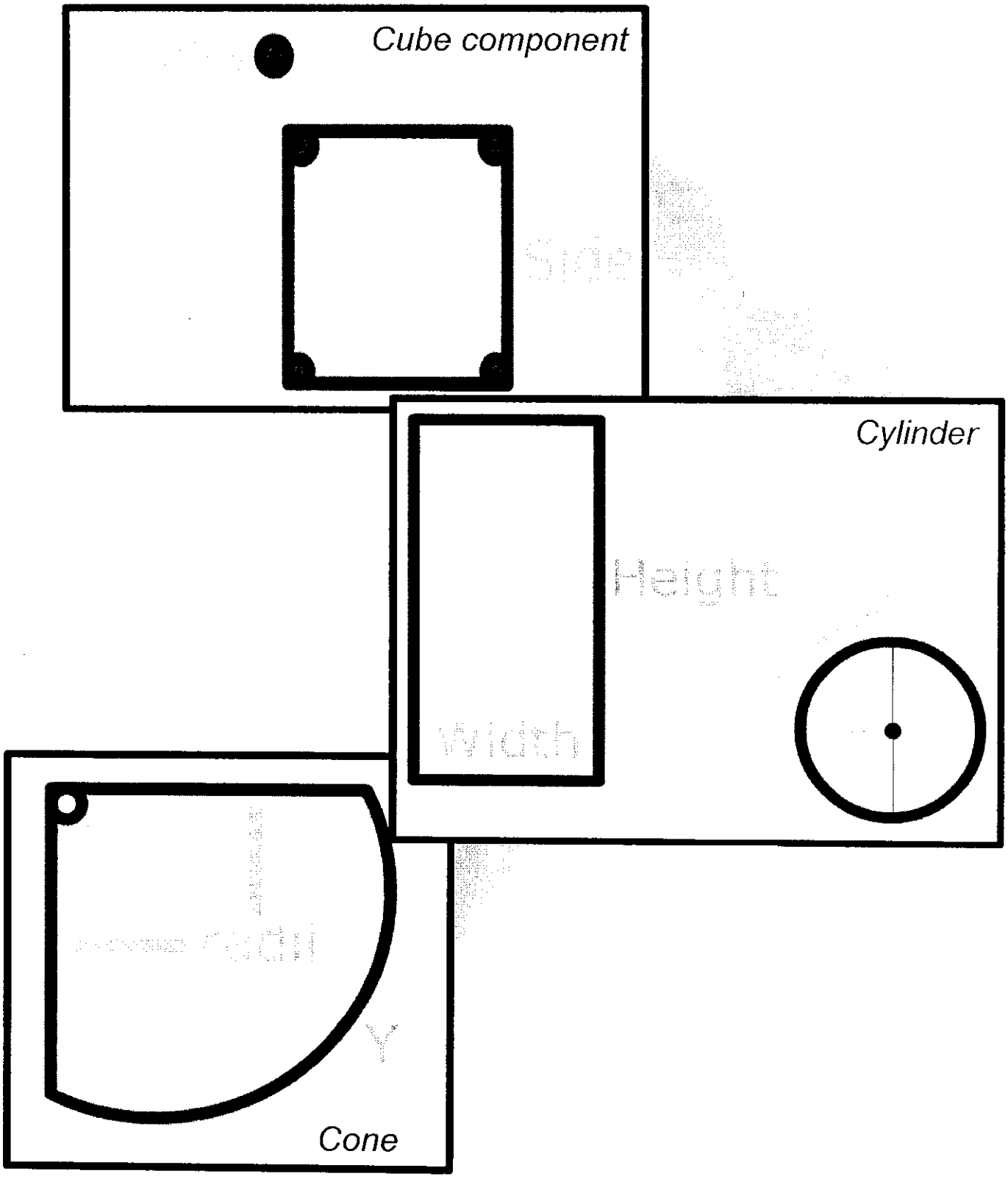
| Independent variable | Dependant variable | Constant variable |
|---|---|---|
| • Height of rectangle | Area of the net | Parallel sides of rectangle equal length. |
| • Width of rectangle | Circumference of round base | Angles inside rectangle (equal) and add up to 360* |
| • Circumference of round base | Diameter of circle | No lid. Only one round base |

## Cone [3]

| Independent variable | Dependant variable | Constant variable |
|---|---|---|
| • Angle [X] | Length of side [Y] | Length of radii |
| • Length of radii | • Area of net<br>• Length of side [Y] | Angle [X] |
| • Length of side [Y] | Angle [X] | Length of radii |

# Diagrams

## Labeling



# Requirements

## Water Tanks

Lids: A water tank does not require a lid; therefore it was removed from the cylinder and cone; on the other hand I kept the lid on the cube, because I felt that the cube would have an advantage over the fact that the lid protects the water inside the cube from pollution.

Welding: In a real life situation – a water tank made out of a net, would be welded at different edges. Therefore, some shapes would have advantages, and disadvantages compared to other shapes. The requirement for having a clear advantage compared to other nets, can be investigated.

# Task: Dimensions

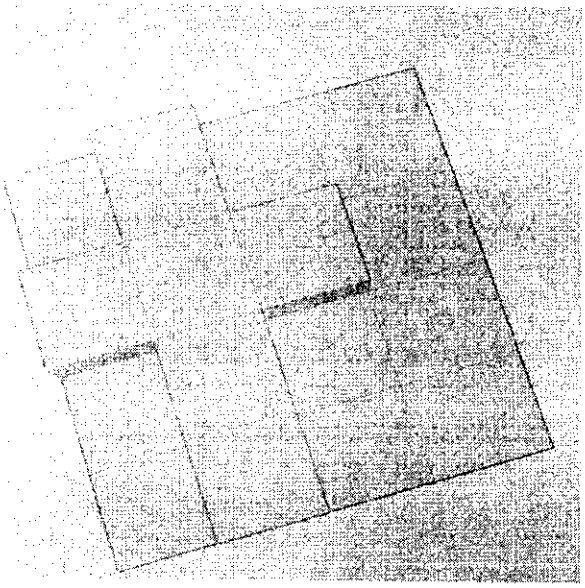
## Nets

So now that I chose the 3 nets, my task is to determine their dimensions

When it comes to nets, you need to be sure you have the right net! Because if you have a net that has a smaller surface area than it *is possible* to get, then the net can be trashed.

## Task: Cube

Before calculating the surface area of the shape's net [and the shape's volume; you have to know the (maximum) length of dimensions available.



The cube is made out of 6 different equal faces.

The sheet of metal I am going to use, to create my net is a "perfect square" - 5x5m.

Because our cube's net consists of 6 squares, we have to divide the square sheet of metal to be able to fit in the net.

Therefore – we divide the square sheet of metal according to my plan.

The principle is simple, because I am creating a net from a cube (all sides of the square faces) equal; I have to follow the rules – and make a net – where each square face has equal dimensions.

There are 3 squares in the width of the net, and 4 squares in the height of the net; and the square sheet should be a "perfect square". The square sheet needs to have 2 equal pair of sides to be a square; if it doesn't – its a rectangle. You split the sheet into equal squares, bearing in mind that the net needs to have a space of 4x3 equal squares. So you divide the square sheet into 16 squares but not 12; that happens because you have to add one more row of squares to the sheet – the sheet has to be a square (all sides equal!)

The sheet is 5x5 meters. You divide both sides by 4, to get 16 equal squares – which are to be used to fit in the net. 5/4 = 1.25 m. Each square is going to have dimensions of 1.25 x 1.25

# Task: Dimensions

## Nets

So now that I chose the 3 nets, my task is to determine their dimensions

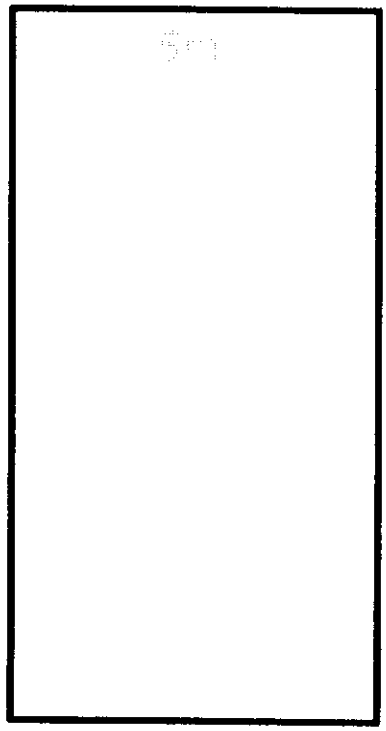
When it comes to nets, you need to be sure you have the right net! Because if you have a net that has a smaller surface area than it *is possible* to get, then the net can be trashed.

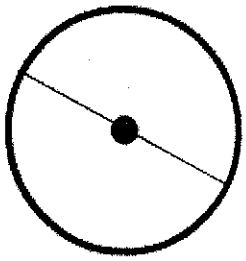
## Task: Cylinder

For the cylinder I removed the lid – unlike the cube. I did this because the net would certainly loose a lot of available area – should it have an extra base.

The cylinder has different variables that apply only to this shape. In my investigation I tried to find out a solution for gathering the maximum dimensions of the net.

I made the width of the rectangle 5 meters (the width of the metal sheet.) If the width of the rectangle is 5 meters, then the circumference of the round base should also be 5 meters (looking back at the variables: the width alters the circumference.) Next, I need to find the diameter of the circle, so that we can find the maximum height of the rectangle.





Circumference = πxd

$d = C/\pi$

$d = 5m/\pi$

$d = 1.591m$

If the diameter of the circle is 1.591m, then the maximum height of the rectangle is [length of metal sheet – diameter of circle]. Therefore we subtract 1.591 from 5 meters. The result is 3.409. The height of the rectangle will be 3.409m, and the width of the rectangle will be 5 meters. These are the maximum dimensions!

# Task: Dimensions

## Nets

So now that I chose the 3 nets, my task is to determine their dimensions

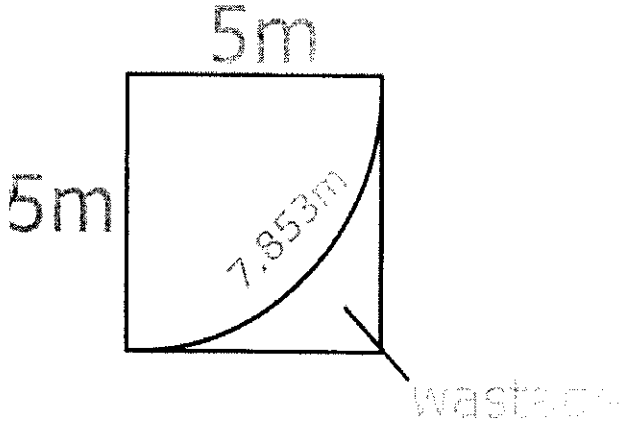
When it comes to nets, you need to be sure you have the right net! Because if you have a net that has a smaller surface area than it *is possible* to get, then the net can be trashed.

## Task: Cone

The cone might seem more complex than the other two shapes, but in fact it has very straightforward variables – they all depend on each other.

To calculate the maximum dimensions of the cone, we have to first calculate the following in order: The angle [Y], the length of the radii.

The angle [Y] should be 90*. Explanation: the metal sheet set in the task is a square – therefore each interior angle is 90*. If angle [Y] will be 90*, that will be the perfect angle, since it does not overstep the boundaries of 90*, nor does it have a deficiency of degrees.




Because the cone does not have a lid, the length of the radii should be maximized to the point of the length of the metal sheet's square – which is 5 meters. Therefore the only surface area wastage would be the space between side [Y] and the corner of the metal sheet. I hypothesize that we have a winner!

Now we calculate side [Y]. Basically side [Y] is the arc of the circle. If it were a full circle, then the radius would be 5 meters; if the center of the circle was angle [X]. Now we can calculate the length of the arc by using the formula:

$$\text{arc length} = 2\pi R\left(\frac{C}{360}\right)$$

R = 5 meters.
C = 90*

2xπx5(90/360)
= 7.853m

Arc length = 7.853m

# Task: Surface Area

## Cube

The cube has 6 square faces. Each face has dimensions of 1.25 x 1.25. Area of square = axb. 1.25 x 1.25 = 1.562m.

Surface area of net = 6 x 1.562 = 9.375$m^2$

## Cylinder

The cylinder net has a rectangular face, and a round base [circle]. To calculate the total surface area we need to calculate the area of the rectangular face and the area of the circle.

Area of rectangle = axb. Area of rectangle = 3.409 x 5 = 17.045$m^2$.

Area of circle = $\pi r^2$. Radius is d/2. R = 1.591/2 = 0.795m.

Area of circle = 1.985$m^2$.

Total surface area = 19.03$m^2$.

## Cone

The cone has only 1 face. This makes matters very simple.

Surface area = angle/360 x $\pi r^2$

90*/360 x $\pi r^2$. Area = 19.632$m^2$.

# Task: Volume

## Cube

Volume = axbxc.

Volume = 1.25 x 1.25 x 1.25.

Volume = 1.953$m^3$.

## Cylinder

Volume = [area of cs] x length.

Volume = [$\pi r^2$] x 3.409.

Volume = 6.777$m^3$.

## Cone

Volume = 1/3 $\pi r^2 h$

Finding the radius of the circular base:

Diameter = C/$\pi$.
Diameter = 7.853/$\pi$.
Diameter = 2.499.
Radius = D/2. Radius = 1.249m.

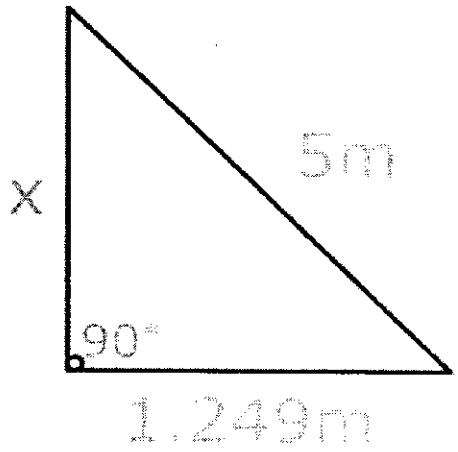
Finding the height of the cone [diagram on the right] :

By using Pythagoras I can solve this problem.

$A^2+B^2=C^2$.
$1.249^2 + B^2 = 5^2$.

$B^2 = 5^2/1.249^2$. B= 25/1.56.

$B^2$= 16.025 = 4$m^2$.




Volume = 1/3 $\pi$ x 1.249$m^2$ x 4

Volume = 6.534m.

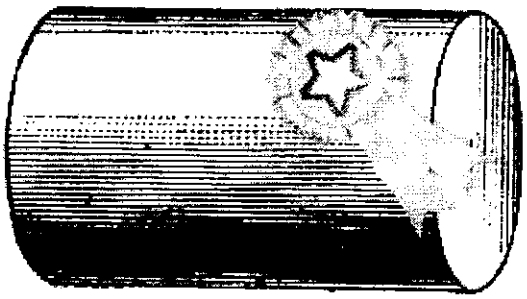
# Conclusion

## Shapes

The cube has a few advantages over the competing two shapes. It is compact, and has a lid – which can protect the stored water inside from different hazards. But overall I dislike the cube. You can see a very big difference between the cube and both; cone and cylinder. First, creating this water tank will be extremely costly, due to the fact that the material wastage is very big ($15.625^2$). It can hold about 2 metric tons of water compared to the 6.7 tons the cylinder can hold. The result; low volume capacity & lots of sheet wastage.

The cone has different advantages when compared to the cylinder. First, it has only one face! It will be very easy to create it, and the volume is nearly as large as the cylinder (6,534 liters [to] 6,777 liters).The surface area wasted is under 5.4 $m^2$, compared to the 5.9$m^2$ wastage of the cylinder. The biggest disadvantage is probably the volume capacity. Even though the difference is very low, there is still a difference of 243 liters. The second disadvantage is its shape. It would be impossible to keep the tank balanced on the ground since it doesn't have a base, so it would have to be kept buried in the ground; neither can it be underground because it has no lid!

The cylinder is the winner. It has the largest volume (6,777 liters) and most important of all, it is also easy to create; only 2 faces to weld. It also has a steady base. The only disadvantage is that it has no lid to keep harmful hazards out of the conserved water. And of mention; it is also impossible to keep it underground by the same reason the cone cannot be placed there either – it has no lid.



# Results

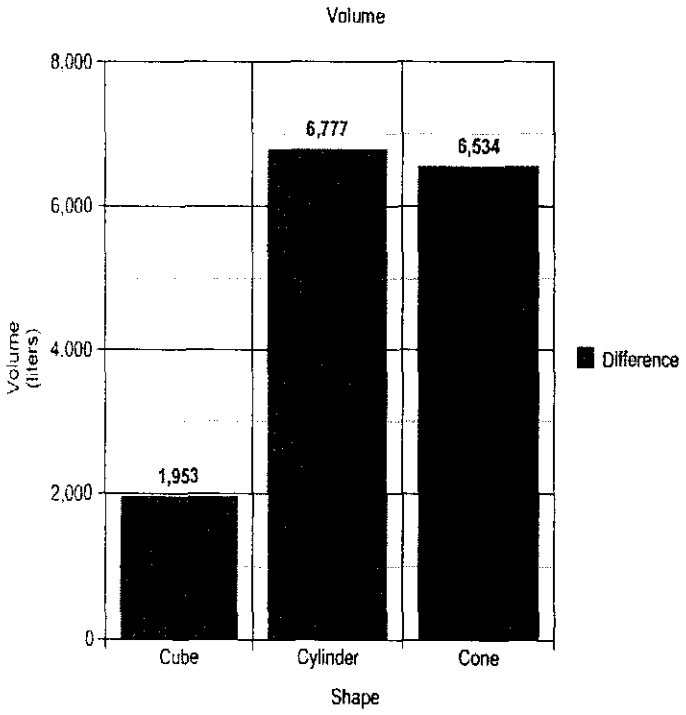
## Table

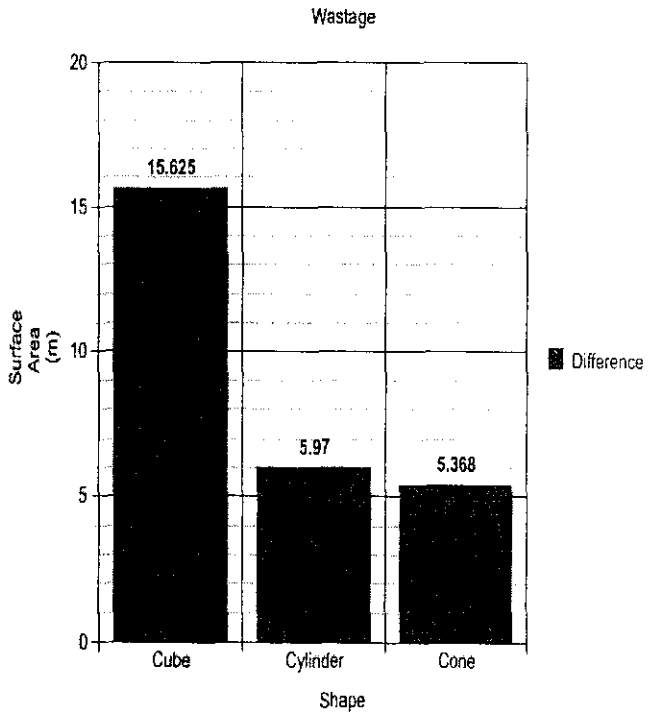
| Shape | Surface area of net ($m^2$) | Surface area wastage ($m^2$) | Volume($m^3$) | Volume (liters) |
|---|---|---|---|---|
| Cube | 9.375 | 15.625 | 1.953 | 1,953 |
| Cylinder | 19.03 | 5.97 | 6.777 | 6,777 |
| Cone | 19.632 | 5.368 | 6.534 | 6,534 |

From the table above you can make an obvious conclusion. Since an obvious conclusion does not make a difference to your final thought, you have to bring in the advantages and disadvantages of the competing water tanks.

## Advantages/Disadvantages

| Shape | Advantages | Disadvantages |
|---|---|---|
| Cube | • Lid<br>• Rigid structure | • Small capacity<br>• Wastes material<br>• Many components |
| Cylinder | • Biggest volume<br>• Few components | • No Lid |
| Cone | • One component<br>• Large volume | • Unstable base<br>• No face |



# Research

## Countries

Water tanks are meant to store, conserve, and protect water from various hazards; such as heat, microbes, and poisonous particles. Water tanks are chosen using these steps.

1. Localization of water tank (Indoors, Outdoors, Underground)
2. Volume of water tank
3. Usage of water (drinking, irrigation)
4. Temperature of environment

I chose Africa as my continent of interest; since there are many water related problems located in that continent. I would like to make the point clear; drinking water is a very big issue. Since the spread of population to remote area, proper dispersal of water between the populations became very hard. The main problem – is the budget. Water tanks are scarce, but purified water is even harder to get hands on. During my research I have read very discouraging stories of the people living there. Women who have to literally travel miles to bring back only just a few gallons of water... Conflict over water resources lead even to wars between the communities... It is really an ecological disaster! My task is to create the best water tank; using knowledge about the design, and practical use of my water tank.

## Water Tank

The water tank (cylinder shaped) should be located indoors, because it has no lid to protect it from different environmental hazards. The water tank should be buried underground to keep a cool temperature – and prevent the water from evaporating; since the environment's temperature is very high in a place like Africa (over 35* Celsius)! Water can be poured in using conventional methods, the main problem would probably be bringing the water to the water tank, so new ways of transport should be created.

# Evaluation & Reflection

## Evaluation

I would like to begin with the process. The most difficult part I found in this assignment was organizing the different sub-tasks, and then combining them in the right order. So instead of following a linear style completion, I tried multitasking. Then I would organize the data, and make necessary changes. The next difficulty I was facing; was choosing – choosing from the available list, of all those different possibilities. The topic is very broad, and so brainstorming was necessary to begin with. Time management proved useful at the beginning but the process was slacking off at the end, because in my planning stage, there was a very big gap between the completion of the project and the creating of the water tank. That is why, I got very nervous in the investigation part, because I did not know what to do. That is when I went back to my investigation, and created my own time line of the sub-tasks I have to complete. This made things easier. During the creating of the water tank I employed several methods of finding out the results; nets, volumes, and surface areas. Once I had my results, I looked back, and made a conclusion. I used diagrams, and pictures to illustrate my point. I also implied different points of view in the conclusion, rather than opinion; critical thinking.

I would also like to evaluate my write up. I think that it was very organized, but lacking in my personal opinions on the matter. Next time I would like to improve the characteristics of my work such as: personal opinions, step by step evaluation etc. Also I would like to improve my knowledge of the subject before beginning it. I wasted lots of time, finding formulas, converters, and unknown mathematics necessary for the completion of the project.

## Reflection

Time management was the first priority. Because the project required a lot of thinking, patience, and organization, time was the main enemy. In this project I had made a breakthrough through the organization of data – I used a completely new way of laying out my write up. The new program I used "OpenOffice Draw" helped me create very complicated layouts with fast precision. The only problem with this new program, is because it is my first time I am using it, and because it required a lot of skill; which I did not yield at the beginning of the project. So instead I just did my write up in Word, the media (pictures, diagrams etc.) in Photoshop, and then I would use this layout tool to stick everything together in order. I would like to reflect on the organization; I believe the new way of organizing date through "OpenOffice Draw" was fascinating. All of those new possibilities I did not even imagine when using plain old Word opened up.
The most interesting thing, is that the winner between the competing shapes was the cylinder, and my bet was the cone. In fact I was very confident the cone is going to have more volume. But again stating the obvious – for so many centuries, conventional water tanks were always cylindrical in form! No wonder, the other shapes lost the competition. Someone, at some time, must have certainly concluded that the cylinder is the best shape for use in a water tank.

# Bibliography


Math Open Reference. Arc Length Definition. Last updated: 2007. Used: 18th October.
<http://www.mathopenref.com/arclength.html>

Math is Fun! Areas. Last updated: 2008. Used: 15th October.
<http://www.mathsisfun.com/area.html>

The MSDS Hyperglossary. Volume Converter. Last updated: 2006. Used: 25th October.
<http://www.ilpi.com/msds/ref/volumeunits.html>

Wikipedia. Water Tanks. Last updated: 2008. Used: 12th October.
<http://en.wikipedia.org/wiki/Water_tank>

Helium. Water problems. Last updated: 2008. Used: 1st November.
<http://www.helium.com/items/1011900-water-problems-for-africa-why-every-day-is-earth-day-there>

Google. Images. Last updated: 2008. Used: 15th October - 10th November.
<http://www.images.google.com>